NOTE

EFFECTS OF FIELD APPLICATIONS OF PARAQUAT ON DENSITIES OF *PANONYCHUS ULMI* (KOCH) AND *NEOSEIULUS FALLACIS* (GARMAN)[1]

Key Words: European red mite, *Panonychus ulmi, Neoseiulus fallacis,* paraquat, apple.

J. Agric. Entomol. 3(4): 322-325 (October 1986)

Neoseiulus fallacis (Garman) is the most important acarine predator of the European red mite, *Panonychus ulmi* (Koch), in sprayed apple orchards in the eastern United States [Poe, S. L., and W. R. Enns. 1969. Predaceous mites (Acarina: Phytoseiidae) associated with Missouri orchards. Trans. Missouri Acad. Sci. 3: 69-82; Berkett, L. P., and H. Y. Forsythe. 1980. Predaceous mites (Acari) associated with apple foliage in Maine. Can. Entomol. 112: 497-502]. Populations of this predator are often present only at very low densities in Virginia orchards, however. The herbicide paraquat has been shown to be toxic to *N. fallacis* using slide-dip bioassays [Rock, G. C., and D. R. Yeargan. 1973. Toxicity of apple orchard herbicides and growth-regulating chemicals to *Neoseiulus fallacis* and twospotted spider mite. J. Econ. Entomol. 66: 1342-1343; Hislop, R. G., and R. J. Prokopy. 1981. Integrated management of phytophagous mites in Massachusetts (U.S.A.) apple orchards. 2. Influence of pesticides on the predator *Amblyseius fallacis* (Acarina: Phytoseiidae) under laboratory field conditions. Protect. Ecol. 3: 157-172]. Paraquat is commonly applied in Virginia apple orchards in early spring while *N. fallacis* is still in its overwintering site in the orchard ground cover. The purpose of this study was to determine if field applications of paraquat affect densities of *P. ulmi* and its predator, *N. fallacis,* in the tree canopy. Slide-dip bioassay data, while very useful for comparing toxicity from topical applications of pesticides, are highly artificial and do not reflect other factors in mortality (contact with dried residues, behavioral responses, habitat modification). Other methods should be employed to complement slide-dip data (Dennehey, T. J., J. Granett, and T. F. Leigh. 1983. Relevance of slide-dip and residual bioassay comparisons to detection of resistance in spider mites. J. Econ. Entomol. 76: 1225-1230).

A 0.4-ha block of apples (*Malus* × *domestica* Borkhausen) at Steeles Tavern (Rockbridge County) was used for a differential herbicide regime in 1984 and 1985. On 11 May 1984 four rows of the orchard block were treated with a mix of paraquat dichloride 2 L (4.7 liter formulation per 100 liters) and simazine 80W (5.6 kg formulation per 100 liters). The remaining four rows were treated with simazine alone. Sprays were applied in 152 liters of finished spray solution per hectare with X-77 surfactant (62 ml per 100 liters), using a Century power-take-off orchard weed sprayer. Glyphosate 4L (6.2 liter formulation per 100 liters) was applied to the entire block in the fall of 1983, 1984, and 1985. Treated strips extended 0.91 m on each side of the tree row.

In 1984, mites were sampled from eight trees per treatment, two each representing the varieties 'Red Delicious', 'Golden Delicious', 'York', and 'Stayman'.

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[1] ACARI: Tetranychidae, Phytoseiidae, respectively. Accepted for publication 9 October 1986.

One 20-leaf sample was collected from each tree; mites were removed using a leaf-brushing machine. *Panonychus ulmi* (motile forms and eggs) and *N. fallacis* were deposited on a sticky glass disk and were counted against a grid pattern on one-quarter of the disk surface under a binocular microscope. Counts were made on 12 June and 10 August.

In 1985, only 'Red Delicious' trees were sampled. The number of trees sampled for this variety was increased to six. This was in order to increase the probability of detecting *N. fallacis*. Similar sampling procedures were used except that when the disk was placed under the microscope for counting, the entire disk was quickly scanned for phytoseiids before subsampling for *P. ulmi*.

No differences in *P. ulmi* densities were seen on the first sampling date in 1984 (Table 1). By August, however, densities of active forms of *P. ulmi* were significantly greater by almost four-fold on trees with paraquat-treated ground cover. Densities of *P. ulmi* eggs were twice as numerous on trees with paraquat-treated ground cover. No phytoseiids were detected on either sampling date. The leaf-brushing technique may have been less efficient at sampling phytoseiids than tetranychids for two reasons. First, counting only 25% of the disk may have missed predators because of their low population density. Second, their more cursorial habits may enable them to escape from the stick disk before being counted. *Neoseiulus fallacis* have been seen walking (albeit with apparent difficulty) across a sticky surface that had entrapped *P. ulmi* (personal observation). Predators could also have left leaves before they were brushed.

In 1985 the entire disk was examined immediately after brushing before subsampling for *P. ulmi* in order to avoid the potential problem of mites leaving the disk before being counted. The trees with paraquat-treated ground cover supported approximately eight-fold and fourteen-fold higher densities of *P. ulmi* motile forms and eggs, respectively, on the first sampling date (the greater mite densities could possibly have been enhanced by a greater population of overwintered eggs in this plot from 1984). Although the *N. fallacis* population density was low, it was significantly greater in trees without paraquat. On the second sampling date, *P. ulmi* population densities (both motile forms and eggs) were still significantly greater in the paraquat-treated area. *Neoseiulus fallacis* population densities in both plots had increased, but numbers were too variable to yield statistically significant differences.

The rows treated with simazine alone contained greater weed densities than did rows with simazine plus paraquat. The most common weed was horseweed, *Erigeron canadensis* Linnaeus.

The results of these field trials are consistent with slide-dip data (topical application only) provided by Rock and Yeargan (1973) and Hislop and Prokopy (1981). Further research is needed on the potential for enhancing populations of *N. fallacis* through manipulation of ground cover management practices. This step may be necessary before orchardists are able to derive full benefit from sparing predators through selective spray programs; if populations are sharply reduced before they disperse upward into the tree canopy, toxicity of airblast applications to *N. fallacis* may be irrelevant.

Adjustments to timing of application may allow integration of this useful herbicide into biological control of *P. ulmi*. Glyphosate was applied to both plots and is toxic to *N. fallacis* according to slide-dip-bioassay (Hislop and Prokopy

Table 1. Population densities of mites in apple orchard canopy following herbicide applications.*

Treatment	Form. per 100 liters	*P. ulmi*		*N. fallacis*	*P. ulmi*		*N. fallacis*
		motile	eggs		motile	eggs	
		12 June			10 Aug		
1984							
Paraquat & Simazine	4.7 liters 5.6 kg	21.6a	138.8a	0.0a	11.8a	15.6a	0.0a
Simazine	5.6 kg	24.7a	118.6a	0.0a	3.0b	6.8b	0.0a
		15 July			23 July		
1985							
Paraquat & Simazine	4.7 liters 5.6 kg	12.5a	10.9a	0.0a	3.3a	12.4a	0.1a
Simazine	5.6 kg	1.6b	0.8b	0.05b	0.9b	1.9b	0.3a

* Data given are mites per leaf. Means followed by the same letter are not significantly different (ANOVA, alpha = 0.05).

1981). If applied in late summer or fall, when *N. fallacis* is still in the orchard canopy, it may have less direct impact on the ability of the phytoseiid to overwinter in sufficient densities. Effects of habitat modification require further research.

ACKNOWLEDGMENTS

I would like to thank Leo F. Ponton and Merrill W. Varn for their assistance with field work in this study.

DOUGLAS G. PFEIFFER
Shenandoah Valley Research Station
Virginia Polytechnic Institute and State University
Steeles Tavern, VA 24476